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An Interpretation of the New Point of View in Science Teaching.*

Otis W. Caldwell.

Persons who have advocated a new point of view in science teaching have constantly been objects of distrust or suspicion on the part of what sometimes seems to be the large majority of science teachers and scientists in general. There seems to be an impression that those under suspicion are personally responsible for bringing upon us a condition of unrest and a feeling of dissatisfaction. This interpretation is far from being true, since the condition of unrest and lack of satisfaction with the prevailing educational procedure is too fundamental to havé been caused by the activities of a few persons. The condition would have developed, possibly not in exactly the same way or at the same time, if none of these persons had been interested in it. The interest in a new point of view of science work in schools has appeared in the work of the N. E. A. Commission on Reorganization of Secondary Schools, the publications of the committee on "A Four-Year Science Course" of the Central Association of Science and Mathematics Teachers, in discussions of a large number of teachers' associations, in the public press, and in the more recent text books published for school use. This interest has appeared independently in many different places and under widely different conditions.

A condition of unrest is not necessarily unwholesome, as is sometimes supposed, provided the condition has arisen from constructive causes. In the history of biological and geological evolution,

* Condensed from an address given before the General Science Club of New England in November, 1916.

the periods of unrest are the ones from which most distinctively new processes and new forms have emerged. In the history of a human individual the periods of greatest disturbance, provided they do not extend to chaotic and undirected expenditure of energy, are the periods from which the individual derives newer ambitions because of discovery of new possibilities. In the physical world a substance in solution may move about, and eventually becomes sediment, precipitate or crystal. It is only while in solution that there is largest possibility of reformation. A condition of unrest in science teaching represents a period of hope and expectation, and presents a most enticing opportunity to persons who really believe in science as a means of public education.

THE HIGH SCHOOL POPULATION.

One of the most fundamental factors which has influenced science teaching is found in the remarkable recent change in the number and status of those who attend the public high schools. Beginning with the first public high school in 1821, it required twenty years for the pupils in all public high schools to reach the number 2526. After seventy years of development, i. e., in the years 1889 and 1890, the total number of public high school pupils in the United States had reached 202,963. It is of especial note that in the twenty years following 1889-90 the number of public high school pupils increased to 915,061, and it is estimated that in the present school year the number of public high school pupils is well toward one and one-half millions. When there is added to these figures the pupils of secondary grade in private schools, it is apparent that the numbers have become enormous, and it is important to determine some of the factors that have had to do with this very great increase in the number of persons who are attending the secondary schools.

CHANGES IN CITIZENSHIP OF THE UNITED STATES.

It is a noteworthy fact that the population of the United States as a whole approximately doubled during each twenty-year period between 1790 and 1850. It approximately doubled again in the thirty years between 1850 and 1880, and almost doubled again in the thirty-five year period between 1880 and 1915.

In the ten-year period between 1900 and 1910 the whole population of the United States increased 11.3 per cent. During this

period, however, the city population increased 34.8 per cent., while the rural population actually declined. In some of the more prosperous agricultural states the population of the state as a whole decreased, except as it was influenced by one or two large cities. It appears that in one or two of the largest states, even when the population of the cities is included, the population of the whole state has actually diminished during the ten-year period in question.

The nature of this changing citizenship has been influenced very largely by the different types of immigration which have been dominant in different periods of the time during which the American public high school has undergone its development. The early immigration to this country was from the English, Dutch, French and Spanish countries. These were peoples who came because of their desire for intellectual and religious freedom, and they were peoples who were ambitious to have their children taught the things which were regarded as fundamental for the development of professional careers. But in the middle of the nineteenth century immigration from the above named countries was greatly diminished, and social, industrial and intellectual disturbances in Ireland, Germany and the Scandinavian Peninsula, together with the appeal that was presented by the unused opportunities of America, stimulated immigration from these countries. Prior to the year 1882 some seven millions of Irish, Germans and Norwegians came to the United States. The influence of these people, as they spread throughout the country, was very great. Their ambitions included not so much those which led toward professional careers, as those which led toward industrial development. Agriculture received a new impetus, but while agriculture had up to this time been the chief occupation, it proportionately began to decline very rapidly in its relative position as compared with the manufacturing and commercial occupations. Beginning in the 80's and continuing until the outbreak of the Great War, the immigration came more largely from Italy, Greece, Roumania, Servia and other Mediterranean Sea countries, at the rate of about a million a year. These working people, as well as those who came previously into the country of new opportunity, began to send their children to the public high school.

THE SCHOOL OF DEMOCRACY.

The million and one-half young people who are now attending the American high school are children of all of these different groups who make up what we call the citizenship of America. Their ambitions are no longer wholly professional, wholly industrial, wholly social, or wholly economic, but all these different ambitions and many others find a place in this melting pot, whose great function is to democratize, socialize, and give real purpose to this hoard of young people. The change in educational ideals has been brought about not only by new thinking about educational problems, but by a fundamental change in the composition of the group for whom our high school education exists. The change in occupations of the people as a whole, the breaking down of the boundary line between city life and rural life, the increased specialization in business, the clearer idea that education must bear a direct relation to the real opportunities of those who are educated, has caused us to re-define the purpose of the high school as a whole. The American public high school must provide the foundational training for all kinds of major activities in which both men and women are to be engaged. It is not expected to give the training that the artisan needs, but to give the general contacts which enable people to know the fundamental things that are involved in these leading occupations and to understand enough about the occupations to enable them to act intelligently with reference to them. The new high school must democratize its pupils. It must stimulate them to purposeful relations to the world's work. It must inform them about the common situations with which men deal, and must lead them to understand that knowledge is valuable in terms of its interpretation into the common affairs of life. The modern high school must open the opportunities for people of artistic and literary ability quite as truly as it does for those who expect to go into industrial vocations. The modern high school is really the opportunity school for the million and a half young people who attend it.

THE SCIENCE SITUATION.

During the time when the public high school has grown to a position of such tremendous importance, science itself has had a notable career. The study of science has called

forth the abilities of some of the best men the world has produced, and their studies have added much to the world's sum of knowledge. The increasing division of science into narrower and more intensive branches has resulted in the production of more and more limited fields of endeavor, with larger research output, in science as a whole. It is to be hoped that this research work may increase, for upon the products of research much of the future of men depends. As the refinements of science have advanced there has been a tendency to introduce into the high school program each of the specialized subjects which have been found advantageous for mature students of science. Since one of the leading purposes of the American public high school is to democratize and to open opportunity to the great mass of young people who make up the high school population, the kind of science which has common interests to all must certainly be used in the high school program. Most of these pupils will not be special students of science. Most of them will encounter constantly the applications of science in their daily lives, from the moment that they rise in the morning until they go to sleep at night. Common life is full of science, but not the kind of science with which the specialist deals. The science of common life is interpreted by use of exactly the method which the specialist uses. We know enough now about the question of formal discipline to teach us that if the method of science is going to be useful in common life it must be learned in the common manifestations of science, and not in the special and unrelated refinements of science. We are facing an entirely different situation from that which was before us when the high school came into existence. We have an opportunity never presented in any other country for the democratic education of the larger part of the young people, who will be influential citizens. Since science has come to be the dominant note in modern life, science itself has the largest opportunity which it has ever held in the history of education. It will use that opportunity or not, determined by whether it faces frankly the problem of using the science of common affairs with which the masses of the people deal, rather than making the futile attempt of imposing upon people the special aspects of science which are properly of interest to special students.

GENERAL SCIENCE.

General Science, as an introductory course in the first year of our high schools, is the most promising of all the subjects which we have attempted in facing this new demand in science teaching.

What are the aims of General Science? Specifically stated, the following are some of the aims which General Science attempts to meet:

To help first-year pupils to a proper understanding and interest in the simpler and common phenomena of the environment as those things appear in the domestic, industrial and social situation with which the pupils come in contact.

To interpret the easily comprehended applications of the special sciences without any regard whatsoever to the place which these applications have in the specialized sciences. General Science makes no pretensions to teaching courses in any of the specialized sciences. It is a course in science for the pupils, not for science. It will undoubtedly be best for science in the long run.

General Science also aims to give the most valuable information about nature, and acquaintance with the methods of solving common problems with the thought that many of the pupils in the first year of the high school may not take any other science work, and need above all to have this point of view by means of which to interpret their environment.

The subject also enables many pupils to discover interests and choose vocations intelligently. It is an opportunity study. It considers science in education as being science for men and the improvement of the affairs with which men deal. But science can improve men and their affairs only as they use the methods and results of science in dealing with their affairs. Men are really educated through and by means of their work or they are not truly educated.

"As an attempt to get back nearer to the world in which the pupil lives, and away from a world which exists only for the scientist, the general science tendency has its justification."

John Dewey.

The High School Situation.

By JOHN F. WOODHULL, Teachers College, Columbia University.

Table showing the number of high schools in the United States at certain Periods:

Number of high schools	Year	Number of high schools	Year
1	1821	160	1870
2	1838	800	1880
3	1843	4158	1890
4	1847	8000	1907
40	1860	13071	1914

The above table shows the high school situation in a nutshell. Such phenomenal growth has of necessity produced conditions which are embarrassing.

Less than one hundred years ago, there was but one high school in the whole United States—The English High School in Boston. It was seventeen years before the second one was established—that was in Philadelphia. Five years later the third one was started in Providence and the fourth one came in Hartford in 1847—26 years after the first one. There were only 40 high schools in the United States in 1860, when some of us were beginning our education. When I began teaching in the high schools there were 800, and when the last report of the U. S. Commissioner of education was issued, there were 13,714. There are at this present date, probably 15,000. Buildings, equipment, and teaching force have not kept pace with that rapid increase in the number of schools. I say unhesitatingly that we are not as well off for rooms in which to teach, nor for equipment with which to teach, nor for teachers as we were 36 years ago. And this is but the necessary consequence of our astonishing growth.

When I began to teach, those 800 high schools were all little affairs, averaging perhaps 25 pupils each. There were not so many high school pupils in the whole country then as there are now in some single high schools. We have several high schools in New York City now that have more pupils than all the United States had when I began to teach. The pupils now number about 1,500,-

000 against say, four or five thousand in the whole country then. Think what the situation was like 36 years ago,—I recall it very distinctly: One was apt to have about 6 pupils in the chemistry class. We had laboratories then as we have now, and with 6 pupils—all American born—homogeneous—there was no reason why one should not do good teaching, at least the best he was capable of. If what some one has said be true, that the instruction which each pupil receives is inversely proportional to the number of pupils in a class, there can be no good teaching in the great high schools of today. When we reflect upon the large number of pupils that a teacher has to handle in each recitation, the large number of recitations each day, the care of apparatus in such large quantities, the necessity of ordering apparatus and supplies a whole year ahead of time and then rarely getting what one orders, the high school situation seems not only embarrassing but impossible. I recall that I secured during the years I taught in the high schools the privilege of buying directly from an appropriation whatever I needed, and I also had the privilege of planning the work—there was no syllabus, and no specific college requirement. It was a free hand for teaching individual pupils according to their needs.

When schools were small, a teacher was not all the while being supervised and super-supervised as at present. A teacher who knew his job was not then handicapped by the supervision of those who knew it not. This is a familiar feature of the great systems of today.

In those days when schools were small, politics did not enter. It was not worth while.

In those days we did not have a mongrel lot of pupils of all races not yet amalgamated. Only those got into the high schools who were fairly alike, intelligent persons, coming from intelligent families.

I do not think the tax-payer is slow in appreciating the value of the schools of today. One third of his taxes goes to the schools and the high schools get about one-fifth of the school tax. We are spending on the education of each high school pupil about five times as much yearly as we did thirty-six years ago but I believe we are giving them poorer instruction.

Another condition which may not be called embarrassing, but which I am sure we do not provide for adequately, is that the girls

predominate very largely over the boys, and we generally plan for the boys and do not think of the girls. The percentage of girls in our high schools is increasing. Ten years ago 48% of the pupils were boys and 52% girls. Today 44% are boys and 56% are girls. And when it comes to graduates, 40% of the graduating classes are boys and 60% are girls. The girls continue longer in the high schools and go to college in about equal numbers with the boys. When I was a college student, a college girl was a rare, not to say a unique thing, anywhere in the country. Almost all the colleges and universities now receive women as well as men. I can at this moment think of but four institutions that exclude women from candidacy for the undergraduate degrees. There are a large number of institutions, chiefly state universities, that have more women than men. The college women seem to be likely, in the near future to gain more prizes, such as election to PBK than the men. And if in the future as in the recent past, men in the community continue to drift into office work and women continue to drift into the control of practical affairs, it will soon be true that women will surpass men in their knowledge of physical science.

Another item in the high school situation, which is worthy of comment is the fact that out of 13,714 high schools, 10,547 are schools with only 3 teachers each. Very few high schools—three or four hundred—have specialized teachers of any particular science. In the face of this fact we have recently undertaken to equip teachers for the schools with that dense ignorance which characterizes specialists. This is doubtless a passing phase in secondary education.

Thirty-six years ago, the value of the books in the high school library was many times the value of the apparatus for science teaching. Now the figures are: 16 million dollars for scientific apparatus against six million volumes in the library. The "scientific apparatus" has not much to do with the interpretation of life and should give place to "commercial stuff", but the most disgraceful thing about the present situation is that the libraries do not contain anything useful. A lot of the high schools have in their libraries no books of science that any one reads. Meanwhile the community outside of the schools is reading much that should gain admission to the school libraries as a real aid to science instruction.

Not only have the schools within the last third of a century become overcrowded with pupils, but they are greatly overcrowded with subjects, the number having increased from half a dozen to more than two dozen in typical high schools.

The greatest cause for embarrassment however is our changing ideas concerning the purpose for teaching any subject. Three or four decades ago, if we wanted to indicate that a man had great knowledge we always attributed to him great powers of memory. President or professor so and so was a wonderfully bright man because he could remember the old students and call them by name whenever they came back to visit alma mater. Afterward it dawned upon us that a table waiter surpassed professors and presidents in the matter of memory. I remember one of the first shocks I got on that theory of education. Many years ago while attending a teachers convention at Saratoga several hundred of us passed into the hotel dining room and a big, burly negro took our hats without checking them. When we came out he astonished us by handing each his own hat. And I said, "What is the use of a college education?"

Some of the Pedagogy of General Science*

By HERBERT BROWNELL, Teachers College, The University of Nebraska.

Advocates of any subject seeking place in the course of study of secondary schools are very properly required to establish especial fitness and value for it, and a manifest superiority in its worth, in order to gain any hearing in its behalf. This of necessity encourages claims that experience has shown are not always fully realized when the subject is taught by those not specially prepared for it, and not enthusiastic in the kind of teaching necessary to its best results. It is quite likely that general science as a high school course will prove no exception to these experiences, however remarkable the results attained may be when in the hands of competent instructors. Teachers scarcely need to be reminded that the warrant for the use of any subject in a curriculum rests primarily in its educational values.

The claims here set forth in behalf of general science are peda-

* Given before the Science Association, State Normal School, Peru, Nebraska, Nov. 25, 1916.

gogical rather than academic, important as its subject-matter may be for the beginnings of secondary school science. One very proper claim to make in its behalf is that it fosters and in some considerable degree establishes with pupils an habitually "scientific attitude" toward their life problems as well as toward their school exercises. This contrasts sharply with teaching efforts that are chiefly if not exclusively for a mastery of the abstractions of scientific knowledge. The subject-matter in general science is primarily for general educational ends. Its classifications and groupings, its continuity and its unity, are accomplished through the interests and activities of the lives of those under instruction. The frame-work of instruction consists of the common experiences of youth rather than the generalizations and theories formulated by the master minds of science. Its requirements are in the field of the experiences and efforts of those under instruction. These requirements should constitute a natural sequence to what is already known by the pupils, and form an introduction to what they naturally desire to know next.

In order to keep in mind relative teaching values, the writer has found it of assistance to assume three fundamentals in the teaching process. It is his conviction that for their attainment, teachers should plan and strive assiduously. They may be briefly stated thus:

(1) A consistent stimulation and direction of pupils to the end that there be firmly established in them *a desire to know*—a life-long desire, dominating all life's activities regardless of occupation.

(2) Such instruction and training *in the procedure for mastery of knowledge* that pupils may not only learn efficiency in the school room, but are fitted *to solve the varied and complex problems of life.* It is possible to so arrange the requirements of the school life that they differ from experiences likely to be met in the later walks of life in degree rather than in kind.

(3) A gradual development in pupils of *confidence in themselves*—a belief in their own ability to do things. This self-confidence in order to be well-founded must be the natural outgrowth of numberless achievements in school requirements. To be suited to such use the difficulties to be mastered in school should have to do with the affairs of life and be real problems rather than artificial creations of the school room. They must not be, on the one hand, so difficult as to discourage, or on the other so easy in their de-

mands upon ambitious youth that they are not considered "worth while", and "a man's job." Such a confidence in one's power to accomplish, when combined with a desire to know, and a knowledge of how to proceed to satisfy this desire for knowledge, is productive both of an *initiative* and a *firmness of purpose* that is likely to accomplish the greater things of life as well as its minor undertakings.

The teaching procedure of general science accords so fully and satisfactorily with these cardinal principles of school instruction that claims in its behalf become more than the extravagant expressions of enthusiastic and over-confident teachers of elementary science. The common experiences of life become at once available in general science as a fund of knowledge of a typically concrete character. In these experiences there has already been established for those under instruction an interest in subject-matter of a most lively sort. A desire to know more becomes a natural outgrowth of conditions.

This knowledge already possessed, and that which is now for the first time to be imparted as instruction given in school, groups itself about centers that are so deeply rooted in the experiences of youth that these teachings will never be forgotten. New relationships, with their demands for insight and association, are possible with each added group of facts from the environment of childhood. A maximum of thought exercise with a minimum of abstractions is at once available for the instructor. Life interests are the centers of instruction, and the artificial barriers of specialized science are no longer teaching factors. Day by day, problem by problem, there may be experienced by the pupil that greatest of all joys—the sense of a power to achieve. Ability to do, and a readiness to undertake, go hand in hand in the work by very reason of its character, and occur naturally rather than as a forced and artificial training.

It is, however, upon the acquisition of those facts that have to do with each requirement of the course of instruction, and upon the discernment of what is vital in the association of these facts—upon all that is involved in what we call "study" in schools, that special stress is to be laid. Study is most assuredly a neglected art. And to have learned to study the problems of life aright, through the formation of effective school room study habits, to have gained both skill and confidence in the mastery of difficulties, is

surely an education worth while. It is education for citizenship and for better living.

The problem presented to the physician in every one of his patients, to the lawyer in every client, to the business man in every change of conditions affecting trade—the problems of the housewife, the farmer, the mechanic, and the financier, may differ widely in the nature of the facts involved, and in the procedure based upon such facts. But in the exercise of an ability to gather the facts bearing upon any of these situations; in the discrimination between facts that are of primary importance and those that need no consideration; in formulating a rational procedure in view of all known facts; and in the execution of any plan formulated, the intellectual powers are exercised in ways that are very much alike. The requirements of a general science course are easily shaped to yield a training in precisely these respects, and the skill and powers so gained actually "carry over" into the affairs of life outside the school.

The attitude of the scientist in any and all walks of life, and in all phases of its activities, goes a step further. Where, for any reason, there is failure to attain desired ends, the scientist reviews his interpretation of facts, remakes his working hypotheses, and again and again as may be necessary tests out his plans. Any study-training of the school room that establishes intellectual habits of this sort is an asset in any of the walks of life. Its value transcends the mere possession of information, howsoever valuable knowledge by itself may be. Indeed, we may properly question the value of any knowledge not available for use as needed.

With many of the branches taught in secondary schools the manner of instruction is fixed, and is scarcely to be changed. With general science there is possible a selection of subject-matter and a manner of instruction that makes its primary purpose in the curriculum actually as well as ostensibly pedagogical. This in no wise lessens the claims justly made for general science as a preparation for the differentiated sciences of the secondary school.

Any lesson preparation that is worthy of being called study requires an understanding of the nature of the difficulties to be mastered. It constitutes a "problem" to be solved. In a choice of topics suited for this purpose there is one of the most serious educational pitfalls of a general science course.

To assemble the facts bearing upon the topics (problems)

chosen; to cultivate a discrimination that takes into consideration only those facts which are essential; to see the various relationships between these facts, and to so organize (group) them as to unify and set forth their significance, is "study" to some purpose. Its very requirements provoke inquiry, and demand constructive thinking.

As seen by the writer, these features characterize the study of general science topics:—

(1) Books are necessary to furnish authoritative information. These are, however, but tools for the worker, and it is in their use as means to educational ends that the worker is to become skilled. It is what can be accomplished through the use of them and their contents, rather than ability to tell what is in them, that marks the real student. For the formation of right habits in the use of books there is required not only persistent effort on the part of the learner, but with most pupils the wise guidance and stimulation of effort on the part of an instructor.

(2) Any study of general science requires laboratory conveniences, and an outfit of simple apparatus and supplies. This makes possible first-hand information concerning common phenomena on the one hand, and opportunity for the verification of explanations of phenomena on the other. Experimental work may at all times illustrate the teachings of the instructor, but more often its great value will be in the demands it makes upon pupils, putting before them very strikingly and very clearly a challenge for the exercise of their knowledge and powers of understanding.

(3) But it is most important of all in the lesson preparation that the teacher take sufficient time—a whole class period if necessary—to get from the pupils what is severally known by them *as individuals* concerning the topic studied. And as these various additions to what is to become *class knowledge* are made, to so relate and unify it all, to so amplify and illuminate it, that it becomes both a means for appreciating further information and an incentive for acquiring it. Any moderate ability on the part of an instructor can accomplish remarkable results in these respects when there is kept in mind all the time the ends sought. On the other hand, the purpose is largely defeated where the teacher fails to organize through discussion what pupils already know. It is not enough for a teacher to be content with subject-matter wholly or largely wanting in association with the life interests of the pupils.

Whatever time is given over to a preliminary discussion of a topic in general science for these purposes, it is desired here to emphasize it as a procedure that constitutes lesson preparation, making out of it a "study period." The topics of a general science course lend themselves admirably to this end. At the same time, the connection between such discussions and simple experimental work by the pupils is so natural that the whole time given over to both may very properly be considered as a "laboratory hour."

The need of the pupil for assistance to understand more fully and to state more definitely what is being discussed, emphasizes the need and the right use of reference books as storehouses of information—a use of them that seeks definite information with an expenditure of the least possible time and effort. The hopeless mental state that results from pouring over material in books that answers no need that has been experienced by the learner, however important this material may have been to the author in the development of some discussion, naturally causes in the learner mental aversion for the subject or mental dyspepsia.

This laboratory time when used as a "study hour" is a procedure for meeting and mastering the "problems of life" that arise in the discussion of general science topics. Variety of treatment becomes necessary as topics change, but the intellectual processes and activities are at all times under the control of the instructor. Lesson preparations of this character provide something very definite and very complete upon which to "recite" later. Further instruction upon a topic studied after this manner, whether to amplify it or to apply the teachings, will find the pupils prepared to receive it. But whatever the topic, and whatever the value of the information grouped in connection with it, *it is the study-training* that general science offers opportunities unrivalled among the subjects for beginners in high school branches. To make its teachings book readings and recitations only, and its experiments merely illustrative of text narrative, is to sacrifice very largely its teaching possibilities.

Bibliography of General Science

W. L. Eikenberry, School of Education, University of Kansas.

The large number of inquiries regarding the literature of general science indicates a widespread interest in the subject. There has been no guide to the growing literature of the subject excepting occasional references by one author to the papers of another. It is in the hope of assisting to make the literature of general science more readily available to students of the movement that the annexed list of citations is published.

The compiler has attempted to include in the list every paper dealing with the general science movement and those cited by writers on general science to the end of 1916. It is doubtless true, however, that many papers which have received only local publication, as in state teachers' magazines, have not come to his attention. It is equally possible that papers which have been published in widely circulated journals and are well known to the compiler may have been inadvertently omitted. Corrections and additions will be welcomed and incorporated in a list of additional citations to be published later.

Citations have been verified so far as possible, but in some cases the original publication was not available. Notice of errors will be appreciated.

A number of papers which are concerned primarily with collateral movements in other subjects have been included on account of their bearing upon the general science movement. It is believed to be important for the student of the general science movement to become familiar with efforts at unification of other subjects, as mathematics.

No books are included in this bibliography, whether textbooks on general science or general educational works in which general science may be discussed. Neither of these sources should be neglected, but they are not within the scope of the present paper.

Atwood, W. W. The first year general science course in the high school. S. Rev. 19: 119-127, 1911.

Abbreviations of Magazine Titles used:
G. S. Qr., General Science Quarterly.
S. Sci., School Science and Mathematics.
S. & Soc., School and Society.
S. Rev., School Review.
Ed. Rev., Educational Review.
N. S. Rev., Nature Study Review.

Austin, R. O. The need and scope of a first year general science course. S. Sci. 11: 217-224.

Avery, Lewis B. General science in the high school. S. Sci. 11: 740-744.

Barnes, C. R. Sciences in the high school. S. Rev. 6: 643-658, 1898.

Barber, Fred D. The physical sciences in our public schools. In Normal School Quarterly (Bloomington, Ills.) Oct., 1913, pp 1-32.

Barber, Fred D. The present status and real meaning of general science. S. Rev. 23: 9-22, Jan., 1915; S. Sci. 15: 218-224, 302-307, March and April, 1915.

Barber, Fred D. Fundamental considerations in the reorganization of high-school science. S. Rev. 24: 724-734. Dec., 1916; G. S. Qr. 1: 102-111, Jan., 1917.

Bigelow, M. A. General science, nature study and biology. N. S. Rev. 11: 241-246, May, 1915.

Bray, W. J. A study of the first class high schools of Missouri. Normal School Index, Kirksville, 6: 49 et seq., Feb., 1915.

Bray, W. J., A study of science teaching in Missouri high schools with special reference to general science. S. Sci. 15: 685-689. Nov., 1915. Report adopted by Mo. Soc. Teach. Math. & Sci., Nov., 1914.

Briggs, Thos. H. General science in secondary schools. Teach. Coll. Rec. 17: 19-30. Jan., 1916.

Brownell, H. A word of warning in connection with general science. S. Sci. 14: 127-129. Feb., 1914.

Buchholz, J. T. First year science in the high school. In Normal Echo (Ark. St. Norm. School, Conway.) 2: 5.

Caldwell, O. W. General science or special science. S. Rev. 23: 134, 135. Feb., 1915.

Caldwell, O. W. & Committee. Report on a four-year high school science course. Proc. Cent. Assoc. Sci. & Math. Teach. 13: 21-23. Report adopted. Republished. S. Sci. 14: 166-188.

Caldwell, O. W. Investigations regarding general science. High School Quarterly, Jan., 1916, pp. 94-101.

Carpenter, Harry A. General science in the Junior High School, Rochester, N. Y. Part I. Organization and aims. G. S. Qr. 1: 46-53, Nov., 1916.

Chandler, Elma. Elementary science in the high school. S. Rev. 17: 89-96, 1909.

Clark, Bertha M. Humanism and efficiency. Ed. Rev., May, 1914. pp. 486-498.

Cooper, H. C. An introductory science course for elementary schools. S. Rev. 9: 440-445.

Coulter, J. G. An N. E. A. Report on high school science. S. Sci. 14: 732-733, Nov., 1914.

Coulter, J. G. A four-years' course in science in high schools. S. & Soc. 1: 226-233. 1915.

Coulter, J. G. The training of elementary science teachers. S. Rev. 24: 26-36. Jan., 1916.

Coulter, J. G. Proposed status of science instruction in the junior-senior high school organization. Ed. Ad. & Sup. 1: 639-645. Dec., 1915.

Coulter, J. G. The organization of elementary science. Sch. & Home Ed., 1915, pp. 369-376.

Coulter, J. M. The mission of science in education. S. Rev. 23: 1-9, Jan., 1915. S. Sci. 15: 93-99. Feb., 1915.

Coulter, J. M. What the university expects of the secondary school. S. Rev. 17: 73-84. 1909.

Coulter, J. M. Correlation of science studies in the elementary schools. S. Rev. 4: 65-69. 1896.

Downing, E. R. The scientific trend in secondary schools. Science 41: 232-237. Feb., 1915.

Downing, E. R. Nature study and high school science. S. Rev. 23: 272-274. 1915.

Downing, E. R. Some data regarding the teaching of zoology in secondary schools. S. Sci. 15: 36-43. Jan., 1915.

Dewey, John. Methods in science teaching. G. S. Qr. 1: 3-9. Nov., 1916. Also in Proc. N. E. A., 1916.

Eikenberry, W. L. The general science course in the University High School. S. Rev. 20: 217-227. Apr., 1912.

Eikenberry, W. L. First year science in Illinois high schools. S. Rev. 21: 542-548. Oct., 1913.

Eikenberry, W. L. Introduction to agriculture. Proc. High Sch. Conf. of the Univ. of Ills., 1913, pp. 62-71.

Eikenberry, W. L. Some facts about the general science situation. S. Rev. 23: 181-192, Mar., 1915.

Eikenberry, W. L. Further discussion of general science. S. & Soc. 1: 417-420. Mar., 1915.

Elhuff, Lewis. Relation of general science to later courses in physics and chemistry. G. S. Qr. 1: 17-22. Nov., 1916.

Fairbanks, H. W. Physical geography versus general science. S. Sci. 10: 761-772.

Garber, J. F. Plant studies should precede animal studies in a course in general science. S. Sci. 14: 240-244.

Glenn, Earl R. Physics in the grades below the high school. S. Sci. 14: 666-672.

Gray, J. C. A general science course of elementary physics and mathematics combined. S. Sci. 12: 377-380.

Greenlaw, Frank W. Obstacles in the path of general science. G. S. Qr. 1: 35-36. Nov., 1916.

Herre, Albert C. "Detested science" in the high school. A reply to Percy E. Rowell. S. Sci. 11: 168. Feb., 1911.

Hessler, J. C. General Science in the first year. S. Sci. 16: 407-411. May, 1916.

Hessler, J. C. How can I teach general science? S. Sci. 16: 518-523.

Hofe, Geo. D. von. General science is project science. S. Sci. 15: 751-757. Dec., 1915.

Hofe, Geo. D. von. Giving the project method a trial. S. Sci. 16: 763-767. Dec., 1916.

Hook, Flora E. General science in East Side High School, Newark. S. Sci. 16: 796-804. Dec., 1916.

Jessup, W. A. Specialization in high school teaching. Midland Schools, 28: 169-171.

Jessup, W. A. & Coffman, L. D. North Central High Schools. In 13th Yearbook Nat. Soc. for the Study of Ed. Pt. I, 11. 73-115.

Johnson, Jr., A. C. Selection and Arrangement of Material in a General Science Course. G. S. Qr. 1: 83-88. Jan., 1917.

Jordan, D. S. Science in the high school. Pop. Sci. Mon. 36: 721-727.

Judd, C. H. The meaning of science in secondary schools. S. Sci. 12: 87-98.

Kilpatrick, E. General science in the high school. Oregon Teachers' Monthly, 1915, pp. 629-635. Report of Comm. of Ore. State Teach. Assoc.

Kilpatrick, W. H. Project Teaching. G. S. Qr. 1: 67-72. Jan., 1917.

Lewis, E. E. General science in Iowa high schools. S. Rev. 24: 426-435.

Linville, H. R. Relations of the sciences in the high schools. S. Sci. 8: 777-778.

Lott, Dwight W. A Twenty Minute Project. G. S. Qr. 1: 122-126. Jan., 1917.

MacCaughey, Vaughan. Natural history in the educational program. Education 36: 220-224. Dec., 1915.

Main, Josiah. The sequence of sciences in the high school. Pop. Sci. Mon. 83: 158-163.

Mann, C. R. Physical geography versus general science. S. Sci. 11: 17-19.

Mann, C. R. Project teaching. G. S. Qr. 1: 13, 14. Nov., 1916.

Masters, F. G. Elementary science—its value and place in the secondary school curriculum. S. Sci. 11: 718-723.

Mead, Geo. H. Science in the high school. S. Rev. 14: 237-254. 1906.

McAuley, Faith. Results of an experiment to determine the content and appeal of first-year science. S. Sci. 11: 14-15.

McClellan, J. H. Physics in the grades below the high school. S. Sci. 14: 504-584.

Millikan, R. A. The elimination of waste in the teaching of high school science. S. & Soc. 3: 162-169. Jan., 1916.

Moore, J. C. Project science, progressive. S. Sci. 16: 686-690.

Moore, J. C. Projects. G. S. Qr. 1: 14-16. Nov., 1916.

Morrison, H. C. Reconstructed mathematics in the high school. In 13th Yearbook Nat. Soc. for the Study of Ed. Pt. I, pp. 9-31.

Myers, G. W. Educational movements and general mathematics. S. Sci. 16: 97-105.

Nightingale, A. F. Report of the committee on college entrance requirements. N. E. A. Rep. 1899. pp. 625-818.

Orr, Wm. and Committee. General Science bulletin. G. S. Qr. 1: 37-46. Continued in later numbers.

Patton, L. M. An experiment in Eighth Grade Science. G. S. Qr. 1: 73-82. Jan., 1917.

Peabody, Jas. E. Preliminary report of the biology sub-committee of the N. E. A. S. Sci. 15: 44-52.

Peabody, Jas. E. and Committee. Revised report of the Biology Committee of the N. E. A. Commission on the Reorganization of Secondary Education. S. Sci. 16: 501-517.

Peabody and Woodhull. The N. E. A. report on high school science. S. Sci. 14: 820.

Reeve, W. D. Unification of mathematics in the high school. S. & Soc. 4: 203-212.

Richardson, H. A. Some experiences in teaching general science and physiography. G. S. Qr. 1: 30-35. Nov., 1916.

Rhynearson, Edward. Science in the first year of the high school. Sch. Jour. (Ives-Butler) 79: 265 ff. May, 1912.

Robinson, D. O. Biology as a unity course in first year science. S. Sci. 15: 717-723.

Roecker, W. F. An elementary course in general science—content and method. S. Sci. 14: 755-758.

Rowell, Percy E. General science. S. Sci. 10: 703-705.

Rowell, Percy E. Why Science in the Grades? G. S. Qr. 1: 53-55. Nov., 1916.

Rowell, Percy E. General science versus physical geography. S. Sci. 11: 116-121.

Rowell, Percy E. Election in high school science. S. Sci. 13: 422-426.

Rowell, Barton and Coleman. The teaching of science below the high school. S. Sci. 14: 711-713. Report adopted by Pac. Coast Assoc. Phys. & Chem. Teach., June, 1914.

Ruch, G. M. Some experimental results in the teaching of elementary science. S. Sci. 16: 49-51.

Ruch, G. M. The General Science Situation in Oregon. G. S. Qr. 1: 126-127. Jan., 1917.

Sheldon, Hudson. First year science. S. Sci. 10: 463.

Shinn, H. B. The movement toward a unified science course in secondary schools. S. Sci. 14: 778-781.

Shull, Chas. A. The relation of first year science to courses in agriculture. S. Sci. 13: 601-610.

Shreiver, Helen B. General science—its character. S. Sci. 16: 736-740.

Snedden, David. Principles of aim, organization and method in general science teaching. S. & Soc. 1: 436-440. 1915.

Snedden, David. General science teaching. S. & Soc. 1: 675-676. 1915.

Snedden, David. The "project" as a teaching unit. S. & Soc. 4: 419-423.

Strong, E. A. General Science teaching. S. & Soc. 1: 562, 563. 1915.

Sutton, H. O. General science in the high school. Neb. Teacher, 19: 24-26. Sept., 1916.

Taylor, Arvilla. General science situation in Iowa and California. S. Rev. 24: 20-25. 1916.

Taylor, Arvilla. The extent of adoption and attitude toward general science. S. & Soc. 4: 179-186.

Thalman, J. L. Some results of a general science course. S. Sci. 12: 192-193.

Webb, Hanor A. Is there a "royal roal to science?" S. Sci. 15: 679-685.

Weckel, Ada L. The present condition of science in the high schools. S. Sci. 11: 406-413.

Whitney, W. W. In what order should science be introducea in the high school curriculum? S. Sci. 11: 95-102.

Whitney, W. W. Science in the high school—an investigation. S. Sci. 13: 183-196.

Whitman, W. G. General science at the N. E. A. G. S. Qr. 1: 58. Nov., 1916.

Woodhull, J. F. General science. S. Sci. 13: 499-500.

Woodhull, J. F. General science—summary of opinions under revision. S. Sci. 14: 600-602.

Woodhull, J. F. Science teaching by projects. S. Sci. 15: 225-232.

Woodhull, J. F. Projects in science. Teach. Coll. Rec. 17: 31-39. Jan., 1916.

Some Phases of the General Science Problem

By N. J. Quickstad, Tech. High School, Virginia, Minn.

The reconstruction of the courses in first-year science is in a state of "becoming." There is no doubt that there is a decided need for a change and I believe that the work is going on in the right direction, despite the complaints and the poor evidence that is brought out. There is no doubt about the fact that there are some miserable attempts at general science teaching and science reconstruction as a whole, but that must be expected until the situation gets better established and a somewhat uniform conclusion is derived in the matter of the problem of text-books, teachers, subject matter, aims, ideals, etc.

One can find, as he looks over the various articles, a great number of reasons for putting in a general science course in the first year of the high school. There is also a wide difference of opinions expressed. Some of the reasons as brought out in the various published articles are:—

(1) Thirty per cent of the high school students drop out before the beginning of the second year. Many of these have had no training in scientific method or facts, not even in physiology, and the general science course will at least give that.

(2) If the student does not continue in school, and has had a course in general science, the pupil will be able to do successful work more ably in the more advanced sciences, such as physics, chemistry, and geology, that come in the later years.

(3) By having been introduced to science by means of such a course, the pupil will be able to make a wise selection in the courses that come later in the high school course.

(4) Such a course gives the pupil and the teacher a splendid opportunity to discover the capacities of the child, which is one of the coming duties of the school.

(5) It should give the student a knowledge of simple scientific facts.

(6) From a psychological viewpoint the more important gain from such a course is the training in scientific method that is necessary to a good understanding of one's environment that will help him adjust himself better to the environment about him.

(7) It gives a background which should be closely connected

with the more advanced scientific work, which is just as pedagogical as the ground-work in Latin, English, or Mathematics.

STATEMENT OF SOME OF THE CONDITIONS THAT HAVE BROUGHT ABOUT THIS PROBLEM AND SOME OF THE THINGS THAT HAVE TO BE CONSIDERED.

Early History of Science Development. This is the scientific age and the introduction of science is relatively, or rather historically, a new or recent adventure. Altho industry can be traced to the early days and in early history one reads about the skilled workmen in the Guild Period, yet if one studies the situation he will find that there is no early co-ordination between science and industry. Science began by asking for explanations in a large way. In the time of the guilds the men were highly skilled but when they would talk about science they would talk about such things as the immortality of the soul, not thinking about objects about them. In fact, there was the widest breach between science and industry. Science became intellectual from a social viewpoint. In the early days when the tribes were isolated, each had its own explanations for the things that happened about them (such as the Saraha desert being scorched by the sun at one time), and when these tribes later began to live in groups they found that each tribe had a different explanation and the idea about the gods or phenomena of nature, etc. They came to the period then of uncertainty and skepticism, which was a necessary step in building up the scientific attitude.

As soon as we come to a place where we realize the life of the other fellow, we begin to see how narrow we are and have been.

Later Development. The scientific attitude is one of the later attitudes that one can come to. The child is not interested in the abstract fact but the reaction that takes place within the individual. We are not primarily scientific or critical. We jump in and speculate, so with primitive man. We patch up something that comes up in domestic life that needs repairs and when we cannot fix it by chance we call on some one to come and help us fix it, without analyzing the thing to see what really is the trouble. The attitude of focusing everything to scientific explanation is a recent achievement, especially in America. The German Committee report after visiting the World's fair held in St. Louis explains

the situation as it appears to be in America—"We have nothing to fear of Americans,—they have no finished products,—they do not know how to apply science to their industries."

General Science Problem. So we haven't a right to believe that the child has the power of focusing his energies with a scientific attitude until the time is ripe for the development of the critical attitude. We sometimes think that the child is scientific because he asks for some explanation. This critical attitude should be developed the latter part of the high school age. This points out the complexity of the science problem in the high school age. The intellectual soil is not right for sowing scientific attitude until you can get the critical attitude. This time is during the adolescent period. This is the period when the general science problem comes in and is to solve the situation.

Man's mastery over the forces of nature and the wonderful achievements of science has recast all of the activities of daily life, completely changing home conditions, the school and its surroundings, every phase in the country, town, and city life; methods of heating, lighting, ventilating, and sanitation; of obtaining food and clothing have changed. The social significance of science in present day life gives it an important place as a subject in our public school curriculum.

The science work in American educational institutions all the way through is designed and planned to furnish a direct path for the training of research workers. This is necessary, but it is also necessary that we do not lose sight of the fact that the needs of the masses of young folk, who are preparing for the ordinary activities of life, receive due consideration.

The percentage of students studying the older sciences in our public schools is on the decline and has been on the decline for the past twenty-five years. (Commissioner of Education Report, 1910 Vol. II. 1139) What is the trouble? What is the remedy?

The trouble seems to be over-specialization. Something has to be done, and the general science movement is a part of the plan to straighten out the science situation in the secondary schools.

Present Status of General Science. During the year 1913-1914 about 300 schools in the United States attacked the problem of revising the science courses by offering general science with many others contemplating doing so. Practically all of these schools were giving but one year of general science while at the present

day some are giving two years of general science and in a few years more will follow.

No generally satisfactory text book has made its appearance, although one or two late ones come nearer to the type that is needed than at first. The difficulty with the text book problem is that for the most part the books are written by university men who are interested primarily in some one of the particular sciences and he writes his book centered around this one subject. It is necessary that the text present a well organized course, as they do in the special sciences, until there is available a supply of teachers who are especially trained to teach the subject.

Subject Matter. The subject matter should be carefully selected and be closely related to the needs of the pupil and common things of his life,—things he sees and handles. It should seek to give him a body of information of significant things, and care should be emphasized in the selection of the matter, according to the past experiences of the child and what he is interested in. If general science is to be of educational value, it must consist of well organized units of instruction. They must be definite and as well organized as are the units of special science. They will be, however, units of practical or applied science instead of units of theoretical science. The course should have unity and logical development taking the pupils in any field of science necessary that is adapted to the adolescent mind, and it must appear as worthwhile to the pupil. It should train in scientific thinking and deal with material with which the pupil is already somewhat familiar, starting from the known to the related unknown. It should give the pupil control of his environment and an appreciation of the significance of science in the modern world.

Difficulties. It can be easily seen that a difficulty arises in attempting to formulate a systematic course based on these fundamental principles because the experiences of the children in various parts of the continent and even in the same city are so different. Then again it would be harmful to emphasize any one of the sciences to too great an extent and it would be disastrous to give the pupils the impressions that they had taken the various science courses in the one course.

Psychological Point of View. In the last analysis looking at the problem from a psychological point of view, it is not so important whether one is teaching biology, physics, or general sci-

ence to these students, as it is important that the scientific attitude is aroused in these adolescents.

General science doesn't guarantee to correct the mistakes of poor teaching. Furthermore we must not expect that these pupils should have an abundance of scientific information that can be used immediately. If we taught a little French, Spanish, Latin, and German in one year in the same course, we wouldn't expect the child to have much language power of interpretation. So with science. We cannot teach science and scientific attitude in the limited time that one year allows. So it seems to me that it resolves itself to the point where we must teach the one phase, namely—the scientific attitude, which should be done not by a little physics and a little chemistry, etc., but by a well organized plan after the material has been carefully selected.

It is very noticeable that the teaching situation in agriculture and domestic science and elementary science in both the grades and high school has changed greatly. There has been an enormous advancement in spite of the fact that the enrollment in the old-line sciences, such as physics, chemistry, physical geography is and has been for some time on the decline.

Studies of children's interest point out that children in the grades and the early high school age are not particularly interested in nature material from the utilitarian point of view. They are interested in the usefulness of such things from the child's point of view,—its usefulness in play,—and not from the so called practical point of view of the adult. The reason for the vim with which children take to these elementary sciences is one of methods of presentation and reorganization rather than content, as most of the subject matter is the same as was previously presented, botany, zoology, etc.—but it is now presented in a concrete form, which tends to bring out conscious order of the chaotic environment of the child.

Science in itself is an impartial presentation of facts. It doesn't stir the emotions or will of the child, until is added to these facts the human relations; which are numerous even within the child's experience. The knowledge of nature's wonderment is important but more important in the introductory science is the training involved in its presentation. The elementary study proceeds from the superficial familiarity with many phases to a more

intense study of certain typical aspects, starting with the environment as a whole.

This approach of intellectual appreciation and apprehension of natural phenomena through the study of concrete situations or projects is in accord with the way the child's mind works. In studying the thinking processes of children, one realized that the natural mode of attack is to group the situation as a whole. Then to comprehend its parts, and later the relationships to each other. Then a second situation is comprehended and analyzed and after many of such experiences and analysis the individual child begins to put together general ideas and arrives at scientific principles.

The scientific organization of subject matter and the working out of the laws and fundamental principles is a later stage in the historical development as has been pointed out earlier and therefore should come at a later stage in the intellectual development of the individual. Children begin to reason moderately early, but reason efficiently only with concrete materials. The abstraction phases in the mental development come later.

Psychologists of the adolescent period tell us that there is a time in the child's mental growth when there is a "coming back" to, or better still, a "going back" to juvenile activity in the growth of sensory and motor brain areas and of the sensor-motor association areas in early adolescence. There would be expected then a renewal of interest in things in a definite situation or in concrete problems and projects. In so far as that is true there is good ground for a renewal of nature study methods in the early years of the high school period. There also comes at the adolescent period marked social changes, that of coming out of the conscious enclosure the child has put himself after finding that society had become critical of him in years previous to the adolescent period. This new interest and coming back into society would cause one to feel that first year science work in the high school should be organized somewhat in nature study lines, in so far at least, as the presentation of matter in concrete situations and projects is concerned and should look toward organization more on the basis of social and also economical principles than is done in the elementary science work in the grade. (There is also this interest manifested in economic conditions when the child "comes out" of the enclosure period.)

Children from 12 to 15 years of age come nearer to all persons

to using the method of great masters of science, and practice the most real research. "The native and unspoiled attitude of childhood marked by ardent curiosity, fertile imagination, and love of experimental inquiry, is near, very near to the attitude of the scientific mind."* So it resolves itself in a complicated problem of teaching, handling the child in such a way so as not to spoil this attitude and at the same time work it and train it so it may become fruitful in the right direction. This same point is brought out in Mr. Ayer's statement found in the survey report of Springfield schools wherein he says, "The greatest problem that the schools are facing is the lack of intimate relationship between the work of the schools and the work of the world. Such work must be real instead of artificial, where pupils are learning something real that has an object behind and a result to come,—they are energetic,—when they listen to, or watch, or read something that is to them artificial they are apathetic. In all of these characteristics the children in our schools closely resemble us adults."

So the science studies must be organized to take care of the child according to his natural mental development and the movement of general science is a protest against the present regime of unorganized subject matter and calls for purpose of instruction to introduce a "psychological organization" which means that the organization of subject matter must be made around the knowledge of the pupil, not around the teacher or the syllabus maker. We have to build on the interests and experiences of the individual, otherwise we are hanging our buildings or hypothetical foundation in mid air.

There are a large number of these children, some dwelling in cities who are stimulated by artificial noises, sights, mechanisms and pictures; others who live in villages or the country, or town where they are amidst a wealth of natural phenomena. Again, they are living in an age and country in which, relatively speaking, a complete explanation of almost unaccountable phenomena has been attained. We must comprehend, describe and classify the wealth of natural phenomena at our disposal and of practical application of science which are to contribute to the methods and means of the study of the general science problem.

We must also study the native capacities, acquired interests, and the powers and probable needs and opportunities of the children

* John Dewey.

whom we are to teach. We must define and test the aims set forth—To gain knowledge of facts, scientific attitude, sense of substantial achievement at the end of the year, satisfaction of curiosity, discovery of cause, realization of use, the rending of practical service, etc. Interest is the great educational magnet which means that the teacher must teach the pupil and not the subject. One of the chief aims in science surely must be the creation of an interest in the daily phenomena surrounding the child. This early introduction to science must handle the situation in such a way that the scientific attitude is brought out rather than the accumulation of a *"bunch"* of facts. It should be handled by a few large topics carried in a systematic way entering whatever field of science it will within the powers and experiences of the child, being elementary and yet significant to the child, and based upon the characteristics of the child and not the subject matter. Some of these characteristics that have to be taken into consideration in handling these youngsters are—that their interest is somewhat superficial spreading over a large area, and not going very deeply. They demand quick returns or their attention will flag. They are optimistic as a rule at this age,—they have studied books all their school days, so if they are to be interested and the course in general science adapted to them, it must embrace more than one line of interest and must include and explain the every-day phenomena of the pupils which it is to serve.

One of the big problems will be to get competent, sympathetic teachers. It is not necessary for a teacher of general science to be a specialist in all the sciences or in any one, but he ought to have some training in each and a large understanding of the child and its peculiar developments. If the teacher is one who is absorbed in one science, the problem is a serious one because he is apt to lose sight of his pupils and be interested only in the less important phases of the situation—namely, the science.

The growth of specialization in present civilization is one of the drawbacks of the present scientific age. It makes or is very likely to make the one absorbed in his special science extremely narrow, which is the source of one of the gravest problems in the present secondary school.

There is need of a general curriculum of science courses so related that there is a continuation of the mental and scientific development based on the introduction of new and more difficult

phases as the mind is further along the field, unifying the experience of the child through the development of systems of ideas. Problems in science must be intellectually apprehended since only when the problems are understood will the science develop. Science courses, the same as mathematics courses in the secondary school, lack the progression necessary for the right development of the mental activities in the science. The way it is arranged at the present time the student studies a little botany and physiography, and then a little physics and chemistry and begins all over in each of these courses with simple problems and simple methods of scientific methods at the beginning, each course beginning as though nothing had ever been done to train the pupil in scientific methods. As a matter of fact the classes are at present mixed, putting in second, third, or even fourth year courses, students who have had three, two, one and no training in science courses previous. The student, in such an arrangement can never realize that there are different degrees of complexity in reasoning. He realizes very slowly, if at all, that the first stage of science study is to collect a few simple facts with a certain degree of accuracy,—the second stage to try and develop some sort of a general principle using the observations made by him,—the third stage, that of verifying the conclusions. What is needed is a realization of the mental processes which represent progress within the science. We need a list of all the different kinds of mental activities that students are called upon to go through in each science,—that there is always some memory work which is necessary for comparison and reason, which comes later,—and the student needs to realize that there is a sequence from memory to reason and a sequence from the simpler stages of scientific mental activity to the later stages.

The period of adolescence which is also the period where individual differences begin to show up, is the time when it is necessary to give the student general courses in all the major fields of human experience. It is a period of general training which will be followed by specialization later on.

General Science for the First Year of the High School *

F. W. Berninghausen, Supt. of Schools, Beaman, Iowa.

The specific sciences, favored by so many educators, do not meet the needs of the ninth grades better than general science because such sciences as taught in secondary schools are defective; first, in regard to text books; second, in regard to the method of teaching; and third, in regard to aim.

High school science text books as a rule are not written by high school educators. We find that by far the greater number of such books are written by specialists in some particular science. While this feature has its strong points, it also has its defects. Scientifically and technically texts written by experts are without fault, pedagogically such texts are often wrong, especially when placed in the hands of the ninth grade pupil instead of mature college people. Let me illustrate my point; we pick up a botany that a botanist has written for secondary school use. All brother botanists proclaim it perfect and recommend it strongly for the place for which it is intended. Next in order is the adoption of this text by a high school because of its authority, and not because it fits the particular need of the one who is to study it.

The proof of a pudding is the eating thereof, and if we apply this principle to the case in hand we are likely to be disappointed. After a start has been made so that the pupil has had a chance to be introduced to his new subject the instructor so often hears this fine text called "Punk" by the boy or girl that starts out on the science. Of course the teacher is horrified; Young America is using his prerogative of free speech and consternation reigns supreme and if asked what is wrong with the book Johnny replies, "I don't see why they can't write a book a feller can read and understand. I read this twice and there are so many big words in it that I don't seem to get head nor tail out of it." If the teacher is wise he will slow up on assignments and give a drill on words and definitions, if unwise he comes to the conclusion that Johnny can never become a scientist anyhow so why bother to explain away the difficulty. In an actual investigation provoked by such a

* Abstract of paper presented before the Biology Section of I. S. T. A. in Des Moines, 1916.

reception it was found that this text contained about 400 words in a glossary appended, and it is only fair to assume that the author used an additional 100 words unfamiliar to the student, making a total of 500 new words for the pupil. The content of the subject matter covered 340 fairly large pages. Now then in one semester this subject called for the learning, defining and assimilation of almost all of these words, and in addition the facts about the science, plus laboratory work twice a week.

Botany out of such a text is called a recognized high school science. It is more than just merely science, it is language, and in this case the most of it was foreign language. To make the comparison clear let me state that when the German teacher was asked to report the new words her class in first year work took up in one semester she found by actual count that it amounted to a little over 500. Because all of these words were German, we call this subject language, in the case of botany we call it science.

Further the content of the recognized science text book invariably shows the predominating influence of the college science, to the exclusion of the common terms and phenomena with which the average boy and girl is familiar. Instead of placing emphasis upon the practical side of the subject the abstract and theoretical is counted most important. Prof. Timbie of Boston makes the statement that this is the common experience in such texts. He further states that: "Text book writers should take the hint from the primary schools, and not despise material with which the boy is already familiar. Phenomena which he can comprehend, and explanations which appeal to his common sense. Let us leave our abstractions and inject subject matter into the course which will contain the leading elements."

Taking up my second point, that high school science is wrong as to method of teaching. All science does not fall under this category as it is now taught, but I do wish to state that physiography, physiology and botany, as taught in the average small high school, is about 90% pure memory work and not scientific work. To get a passing grade in such subjects, a pupil must be ready with answers to the questions put to him, and these questions are based on text book material almost entirely. Let me ask: "Is it scientific to have high school pupils study the text, recite from the text material, cite illustrations of phenomena from the text, and then *sometimes* end up with experiments?" If it is, then high

school science is being taught in the right manner. If this is not science, it fails, insofar as these things are factors. Why would it not be wise to adopt the inductive method in teaching secondary science?

My third point deals with the aim of high school science. The aim of the high school, originally, was that it must prepare the student for college entrance. This aim has not been changed materially, if we except from our course general science and the vocational subjects. In general science and in vocational subjects, the high school is not a secondary school, but a leader, a finisher of the boys and the girls who go to work instead of going to college. The high school has a double task to perform in the way of instruction.

Right here is the parting of the roads to right and wrong education. The college once dictated—"Thou shalt not give general science and vocational subjects." But the high school kept on fulfilling its double mission, until in the case of the vocational subjects the bars were let down and high school credits in these are accepted by the higher institutions. General science is an exception to this, for the reason that it is pure high school science and does not smack too plainly of college science.

Now, in general, let me state that instead of a wide open door through which to enter to science, the high school pupil feels that the door is but half open. Instead of going from the known to the unknown by easy steps, he soon comes to the conclusion that science is one-half guess work on his part, and one-half an endeavor to learn data and learn a new language. The guess work is necessitated in the problems he may be forced to work out by the forms given in the text. He can work the problems easy enough in many cases, but he readily admits that he does not see the reason "why". This is the place in which specific science falls down. The common every-day phenomena is so little understood that almost nothing carries over. But, you say, that in the majority of cases this is not so. All right, for argument's sake we will accept your statement. If your statement is true, why is it that the average college girl graduate, who has studied some science in the high school and some science in the college, and who is now teaching in the high school, most always gives a flat refusal or objects strenuously to teaching high school science. The usual answer is, in such a case: "I did the work; I got through all right; but I never

understood what I was doing. I just can't teach that subject." I have been told by these same teachers that their instructors were simply great in their line of work, but were also so specialized that they failed to get the attitude and viewpoint of their pupils.

Authoritative text books are necessary, and their use is to be commended; but why not get this new science material over to the ninth grade pupil in as natural, in as common every-day language as is possible. Here lies an immense stumbling block in the way of the new scientist. Here is the cause for so much distaste to science. It is not so much the material oftentimes that can be objected to, as it is the manner in which that material is presented. Ladies and gentlemen: We do not object to sciences as they are now offered in the high school, but we do object to the elimination of general science, for the reason that it does not conform to the established kind of science. To object to general science on such a score is to object to something because it is expressed in common language. It is to object to common science because it is of interest to all, and of use to all. It is to object to simplicity, directness, and naturalness. To rule out general science in Iowa at this time, is to say to more than 250 high schools of the state that they are wrong in curricula content. To rule out general science for any reason, is to take a backward step. Progress in education must of necessity be very slow, but nevertheless we progress. It has not been so very long ago that the subject of agriculture was not called a science, no matter where taught. At present it is a recognized science in all institutions of learning. Manual training and domestic science are now taught in practically all secondary schools, and colleges now recognize such work.

Human nature is much the same among all classes of people. College instructors in science departments, are usually loth to admit new science subjects. This is but natural. Further: high school instructors are just as loth to admit new subjects to the already crowded curricula—more nature. But when a subject such as general science, a science of common things, presented in common language, and as common sense dictates, presents itself, it is tried out by secondary educators. It has been tried out and found worth while.

In summary, let me reiterate that recognized sciences, as taught in our secondary schools, are wrong in text books, because these texts are too technical, contain too much material, and are not writ-

ten with the idea of teaching pure high school science. Second: That the methods of teaching recognized science in the schools, is not the inductive method, hence has a weakness. And, third: That the aim of science in the high school, is not broad enough, is not big enough to meet our present need. We do not wish to make specialists and experts out of the majority of high school people, but we do wish to fit them as best can be for all the isuses of life.

"The Project" in Agricultural Education

By F. E. HEALD, Specialist in Agricultural Education, States Relations Service, U. S. Department of Agriculture.

The term *project* has within recent years gained a recognized standing in educational and scientific circles in at least the following particulars which contain several identical points:

1. The *home project* and the *class project* in agriculture, home economics and some science work as adopted and administered in Massachusetts, New York, and other States.
2. The *club project* as used in the co-operative work of the Federal and State forces, in which a season's work along a given line is called a project.
3. The *project* prepared by the scientific investigators in the State experiment stations covering a definite line of investigation, and approved at the Office of Experiment Stations of the U. S. Department of Agriculture.
4. The *extension project* prepared in the States and approved in a similar way in the States Relations Service of the U. S. Department of Agriculture.

Certain terms have grown to have such an established place that it is best not to add confusion by making applications of another nature, although the derivation and dictionary definition would warrant the new use of the term.

The division of Agricultural Instruction has frequent occasion to use the term project as applied to school instruction, and as it does not assume the authority to impose definitions, it has compiled in brief form the requirements which seem more or less common where projects have received serious consideration.

Such a definition which was first printed in U. S. Department

of Agriculture Bulletin No. 281 as applying to home projects, and further developed in Department Bulletin 346, reads as follows:

"The term 'home project' applied to instruction in elementary and secondary agriculture, includes each of the following requisites: (1) There must be a plan for work at home covering a season more or less extended. (2) it must be a part of the instruction in agriculture of the school, (3) there must be a problem more or less new to the pupil, (4) the parents and pupil should agree with the teacher upon the plan, (5) some competent person must supervise the home work, (6) detailed records of time, method, cost, and income must be honestly kept, and (7) a written report based on the record must be submitted to the teacher."

This agrees with the other accepted applications of the term project in the essentials which are briefly described here.

1. The plan must have an aim which is in accord with the general scheme of work, in which the pupil has an interest at the outset and in which there is some problem more or less new. The person who approves the project at the outset should have some broader view of the applications and should shape the general plan accordingly.

2. The project should involve principles already studied or which are studied concurrently with the practice. The discoveries of others should be found out, either by observation or by reference study, and records of these should be compiled. Problems, practicums, demonstrations, and occasional experiments may be necessary as a part of the project. These in themselves may be within the dictionary definition of the term project but we have already these other terms in the vocabulary of education. The exact line of demarcation between a short project and a longer practicum may as well be left undecided, but the tendency to give to everything which may be "projected" or planned the name *project* is unnecessarily confusing.

3. The records and reports covering each of the steps or processes with final conclusions or results should be preserved.

All of these points will apply, whether the project is for an individual or a group; at school, at home, or elsewhere in the community. To start with a definite aim, to do certain correlated lines of work covering a fairly extensive field or period of time, and to bring together everything bearing on the main aim are essential

points in a project. A specimen project here given may be developed either in agriculture or correlated sciences.

A Project—The Profit from a Dairy Cow.

A sample outline without detail.

Project Divisions.	*Items Involved.*	*Correlated Material.*
Milk two or more cows for one month or more.	Sources of milk. Sanitary milking. Care of cows.	Sediment test of milk. Care of milk in the home.
Weigh milk at each milking and record on sheet in stable. Total each week and each month.	Proper use of the spring balance. Factors influencing variations in milk flow.	Daily, weekly, and monthly records of notable cows. Averages for herds and for the State.
Take samples of milk morning and evening twice each week. Observe cautions.	Natural separation of milk. Specific gravity of each part.	Emulsions and their peculiarities.
(Run separator or cool and store the milk as required). Test each cow's milk separately for butter fat at least every two weeks at first, monthly later.	Commercial disposal of milk; making of milk products. Principles of centrifugal action. Sulphuric acid in this connection. Basis of computations.	Specific gravity of liquids. Bacteria in milk. Spread of disease by milk. Applications of centrifuge, drying machine, etc. Acids. Neutralizing.
Compute total butter-fat per cow. Compute total income at the market prices, by the day, week and month.	Composition of milk. Percentage of each part. State or city standards for total solids; for butter-fat.	Milk as food. Value of each part. Relative value compared to other foods.
From weight of cow and daily production, compute a ration and vary until success is apparent.	Digestible nutrients of local feeds. Balancing a ration. Economical rations of home-grown feeds.	Human food. Sources of protein. Clover and other legumes.
Compute cost of rations, cost of care. Credit cow with butter-fat, skim-milk, manure, etc., and find net income for week and month and whole period.	Manurial value of feeds.	Cost of production of other products of domestic animals. Factors included. Labor of horse, eggs, beef, wool, etc.
Compare cows. Compare each with the points in score cards for judging.	Judging dairy cows. Observation trips. Famous cattle.	Types and breeds of cows.

Such an outline may be modified to meet local and personal circumstances. In some schools the main project would be handled by the agricultural course and the related science by the general science course. In another school the project itself might be a part of the science work.

A project might be largely investigational as in the case of sewage disposal or ventilating systems, but the greater the personal activity the relatively greater the value which may be expected.

Whether the application is made to projects in science, agriculture, community civics, or any other subject, it would seem desirable to obtain uniformity for the sake of clearness. The interpretation here given is that used by several State boards in administering the school systems and seems quite generally accepted in sections which have developed such methods of instruction.

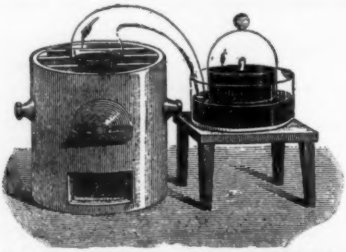
"The best part of all human knowledge has come by exact and studied observation made through the senses of sight, hearing, taste, smell and touch. The most important part of education has always been the training of the senses through which that best part of knowledge comes. This training has two precise results in the individual, besides the faculty of accurate observation—one the acquisition of some sort of skill; the other the habit of careful reflection and measured reasoning which results in precise statement and record. . . . Sciences should be taught in the most concrete manner possible—that is, in laboratories, with ample experimenting done by the individual pupil with his own eyes and hands, and in the field through the pupil's own observation, guided by expert leaders."

Charles W. Eliot.

The First Analysis of Air

Being an account of Lavoisier's celebrated experiment, translated from his own description of it.

"Taking a vessel, or a long-necked tube, with a bell or globe at its extremity, containing about thirty-six cubic inches, I bent it so as to place it in the furnace while the extreme end of the neck was under a glass cover, which was placed in a basin of mercury. Into this vessel I poured four ounces of very pure mercury; and then, by means of a siphon, I raised the mercury to about three-quarters the height of the glass cover, and marked the level by gumming on a strip of paper. I then lighted the fire in the furnace, and kept it up incessantly for twelve days, the mercury being just sufficiently heated to boil. At the expiration of the second day, small red particles formed upon the surface of the mercury, and increased in size and number for the next four or five days, when they became



Apparatus used by Lavoisier in analyzing air

stationary. At the end of the twelve days, seeing that the calcination of the mercury made no further progress, I let out the fire and set the vessels to cool. The volume of air contained in the body and neck of the vessel before the operation was fifty cubic inches; and this was reduced by evaporation to forty-two or forty-three. On the other hand, I found, upon carefully collecting the red particles out of the melted mercury, that their weight was about forty-five grains. The air which remained after this operation, and which had lost a sixth of its volume by the calcination of the mercury, was no longer fit for respiration or combustion, as animals placed in it died at once, and a candle was extinguished as if it had been plunged in water. Taking the forty-five grains of red particles, and placing them in a small glass vessel, to which was adapted an apparatus for receiving the liquids and aëriform bodies which might become separated, and having lighted the fire in the furnace, I observed that the more the red matter became heated, the deeper

became its color. When the vessel approached incandescence, the red matter commenced to become smaller, and in a few minutes had quite disappeared; and at the same time forty-one and a half grains of mercury became condensed in the small receiver, and from seven to eight cubic inches of an elastic fluid, better adapted than the air of the atmosphere to supply the respiration of animals and combustion, passed under the glass cover. From the consideration of this experiment, we see that the mercury, while it is being calcined, absorbs the only portion of the air fit for respiration, or, to speak more correctly, the base of this portion; and the rest of the air which remains is unable to support combustion or undergo respiration. Atmospheric air is, therefore, composed of two elastic fluids of different, and even opposite, natures."

It is not practical to reproduce the first part of Lavoisier's experiments before a class, but an account of it is interesting to the pupils and although the two gases were not named when Lavoisier performed the experiments, pupils will readily see that they correspond to oxygen and nitrogen.

A simple experiment, suitable for seventh and eighth grades, which shows roughly the relative volumes of oxygen and nitrogen in the air is that in which a burning candle, floating on a flat cork in water, is covered with a bottle whose mouth is pressed down into the water. After the oxygen is consumed the candle goes out and water will rise in the bottle to take the place of the consumed oxygen. Close the mouth of the bottle while under water and remove, placing it mouth up. Test the nitrogen with a burning taper to show that it does not support combustion.

The second of Lavoisier's experiments, that of liberating oxygen and mercury from the red powder, mercuric oxide, may profitably be performed as a demonstation or even done individually by the pupils. Place about one-fourth a teaspoonful of the red oxide in a test tube. Hold the tube nearly horizontal and heat only that part of the tube about the red powder in order that the other part of the tube may be cold enough to condense the mercury. When there is a good evolution of oxygen, test with a glowing wood splint to show that it will cause the splint to burst into flame. Continue the heating until a good mercury mirror is seen on the cool part of the tube. This may be scraped off and identified as mercury.

W. G. WHITMAN.

Some Problems of Elementary Science *

By ALBERT EARLEY, Principal of the North Plainfield High School, New Jersey.

In preparing for this discussion today, I was surprised to find that elementary science was discussed by the N. E. A. as far back as 1869; that some Illinois schools have been teaching elementary science for sixteen years. In my ignorance I had supposed that the subject was of more recent origin. However, I believe that it has come into the limelight within the last four or five years. I have been reading School Science and Mathematics since 1908 and until about 1912 there were very few, if any, articles on elementary science. That the interest is becoming keener is evidenced by the appearance of a new journal, "General Science Quarterly", the first number of which has just been issued.

One problem which may confront some schools is to show the need for elementary science. Can you explain to your patrons why another subject has been added to the curricula and why this particular one has been chosen? As science teachers, we would strenuously defend the proposition that at least one science must enter into the scheme of education for every intelligent person. In this we would be backed by Dr. Eliot, who deplores the fact that so many of our professional men lack a scientific education. He points out as an element of weakness in our educational scheme, the fact that so many men otherwise well educated, have never used an instrument of precision. Some subjects will develop mainly the imagination; some the memory, but the sciences stand preeminent in developing the powers of observation, in encouraging an inquiring mind, and in training the reasoning powers. Since some science is necessary, the next question is, what science shall it be and when shall it be given?

Our Assistant Commissioner, Mr. Meredith, states that about fifty per cent of all high school students are in the first year, hence, if the majority of our students are to get any science, it must not be later than the freshman year. I presume that we are all of the same opinion on this point. The reports of the U. S. Commissioner of Education show that at the present rate of decrease, science will have disappeared from all schools in the year 1960. The

* Paper presented at a meeting of the Elementary Science Section of the N. J. State Science Teachers Association, Nov., 1916.

decrease in the number of students studying science, as shown in the same report, indicates that something is wrong. If specialized science is losing its grip, let us try general science. Furthermore, physics and chemistry are highly specialized and are, therefore, not adapted to first year students, but elementary science is.

Another problem is what should be the object of a course in elementary science? On this point there is no agreement. Some say that the purpose is to lay a firm foundation for further work in science and to help the student who finds mathematics difficult. Dr. Eliot has said that the most important aim of education is to furnish opportunities for self-discovery. No other subject in the high school can possibly rival elementary science in furnishing opportunities for the student to discover himself. In teaching the elementary facts of astronomy, we may discover a future Herschel, or a brief course in the elements of Geology or Mineralogy may enable a boy to discover that he has an abiding interest in such things; he may become a Dana. A young man of my acquaintance became interested in astronomy through reading one popular article on the subject. The speaker had a ten weeks' course on insects and one of the same duration on birds, and while he did not acquire an extensive knowledge of either subject, he developed an interest in both which has been retained, undiminished. To the criticism that elementary science gives only a smattering of several things we may reply that it is better to have a taste of all the branches of science than a distaste for all. In an elementary science course, one object has been attained when the students are prepared to choose more intelligently their elective subjects of the later years. Another writer states that elementary science should be a course that will introduce the students to the observing of natural phenomena and the recognizing of natural laws in a manner likely to maintain his interest and to stimulate his growth. It should furnish him with information which he is likely to find useful.

In a course outlined in one educational journal, the pupil studies fractional algebraic equations, involution, evolution, surds, exponents, triangles, circles, quadrilaterals, plotting curves, etc. The idea of this course is that elementary science is intended to bolster up the mathematical weaklings. If elementary science is put on this basis, it must inevitably fail. I, for one, do not believe

that elementary science is intended to act as a review of elementary algebra.

Another writer says: "To a deplorably large part of the community the striking of a match, the freezing of water, the falling of snow, the sending of a telegram, the operation of an engine, involve mysteries as profound as the cause of gravitation."

Lewis Elhuff says that general science has no more relation to future courses in physics and chemistry than it has to future courses in botany, zoology or anything else. Teach the student facts about his own health, the health of the family from which he comes, and the health of the community. A young lady who graduated from high school and college, had studied Latin eight years, Greek seven years, was one of the best mathematicians that ever entered the college, could not tell an oak tree from a pine. At picnics she did not hesitate to eat food over which flies had freely crawled. She was not educated. No one is educated if nature is a closed book to him. Among other things, elementary science should teach common things about the house, such as reading gas meters and putting on ball washers. It should teach the student to read with a greater understanding, much literature which abounds in scientific allusion. He should be able to read more intelligently popular scientific magazines.

If we examine a text-book of trigonometry, we shall find the laws of the sine, cosine and tangent; the formulae for one-half and double the angle, etc., but if we examine an elementary science text, what do we find? What is the author's conception of elementary science? Miss Pease in her book of 1915, devotes 45 pages to the elements of astronomy, 92 pages to the elements of physics; 28 pages to elementary chemistry; 88 pages to physical geography and 52 pages to biology. Barber in his First Course of General Science devotes 175 pages to heat and light; 135 pages to meteorology; 32 pages to ventilation; 175 pages to biology, and no attention is paid to chemistry or astronomy. Miss Clark, in her book of 1912, devotes approximately one-half of her book to physics and the other half to chemistry. For her, elementary science means easy chemistry and physics. Hessler gives one-half of his book to physics and chemistry. In a course outlined in School Science and Mathematics of November, 1912, elementary science is composed of physics and chemistry.

In the selection of the topics to be studied, why not co-operation

between the teacher and students? Is there any better way to maintain interest at the highest pitch than for the students to assist in selecting the subject matter? John F. Woodhull of Columbia University, says that whatever is worth while in astronomy, botany, chemistry, geology, meteorology, physics, physiology, zoology, etc., may be acquired.

An objection which is often urged against elementary science is that it is duplicated by the biology of the second year, or the physics or chemistry of the third or fourth years. If there is undue duplication the objection is a serious one because Dr. Eliot has said that boys and girls lose one and one half years in passing through our schools. This loss is due to the study of useless subject matter. If there is to be a further loss of time or efficiency by duplication, the public will rightly point the finger of condemnation at elementary science. A certain amount of duplication might be justified on the ground that it is a review. Many high schools duplicate their mathematics by a review of algebra and geometry in the second semester of the fourth year. However, I believe that the less duplication we have the better our course will be received by the public. Duplication can be easily avoided if the same teacher has all the science as is usually the case in small schools. Or it may be avoided by proper co-operation among the various science teachers or by the superintendent outlining all science courses. Bayonne avoids duplication by giving two years of elementary science based on the biological sciences and devoting the last two years to the specialized physical sciences. In some schools there is little chance of duplication in the case of most commercial students, because, while most of them elect elementary science as freshmen, very few elect the specialized sciences of the third and fourth years.

Another problem confronting some schools is lack of equipment. However, the ingenuity of the teacher should overcome very largely this difficulty because the equipment required for elementary science is not complicated.

Another problem is the dearth of properly trained teachers. Time will, no doubt, solve this problem.

Many teachers, if left free and unrestricted, will teach those divisions of their subject which they like best or in which they are especially well prepared,—hence, another problem is proper supervision so that the over-enthusiastic chemistry or physics devotee

shall not teach formal chemistry or physics when he should be teaching elementary science and making use of chemical and physical subject matter. In other words, it will sometimes be necessary to guard against an over-emphasis of one phase of elementary science at the expense of the others. This can be done either by supervision, an inspection of the teacher's plans, or by a definite course outlined by the superintendent. If this is not done, general science will lose one of its chief claims; i. e., that it is general: it will become special. The writer knows one teacher, an ardent advocate of evolution, who, while teaching general science, carried evolution so far that the clergy of the community said that she was teaching heresy. Surely this was a case for supervision.

In the small high school, the teacher of elementary science is usually the teacher of the other sciences and hence, besides his regular class work he has laboratory work in physics, chemistry or biology, and no time for any laboratory work in elementary science. But any science work to fulfill its highest mission must of necessity contain some laboratory work: the pupil must acquire a working knowledge of laboratory methods. A science course which neglects this, is not science, it is simply a revival of conditions of fifty years ago when science meant the mere study of a text-book. And yet, the speaker knows of elementary science courses which make no provision whatever for laboratory work.

As the writer sees it, general science is an attempt to break down the watertight compartments which have heretofore existed in our science teaching. These watertight compartments do not exist in nature, why should they exist in the school room? The mathematics teachers are coming to the idea of first year mathematics, second year mathematics, etc., instead of algebra, geometry and trigonometry being taught separately.

We may summarize as follows:

There must be a more general agreement as to subject matter.

There must be a more general agreement as to the object which is to be attained.

Avoid undue emphasis on any one topic.

Avoid or minimize duplication.

Make some provision for laboratory work.

Time will solve some of these problems; conferences and the columns of the General Science Quarterly will solve the others.

Home-Made Apparatus *

Herbert F. Davison, Head of Science Department,
Pawtucket, R. I., High School.

The pieces of apparatus illustrated in this article were shown by the writer at the Rhode Island Normal School, Providence, on January 13th, before a gathering of teachers interested in the subject of general science. So far as is known, they have never been illustrated in any book in the form here given.

The writer thoroughly believes that there is only one proper method of teaching general science to young pupils and that method is the one in which the teacher performs all the experiments before the class and then discusses the practical applications of the principle shown by the apparatus. This necessitates having considerable apparatus, and a teacher of some skill and dexterity in the handling of it. The latter is not always easy to get, but the former can be frequently made by the teacher, utilizing odds and ends found around the laboratory. Much can be done in elementary work with very cheap apparatus, because qualitative results in general are all that are aimed at.

These four pieces, selected from many that we use in Pawtucket High School, will be found to show clearly the principles they were designed to illustrate, and with little expense.

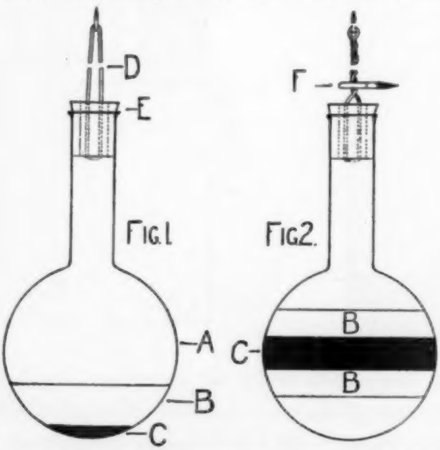


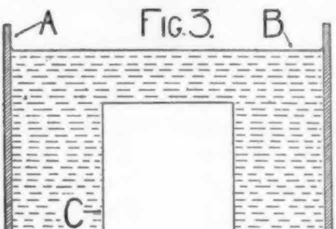
FIG. 1 FIG. 2.

Figures 1 and 2 illustrate a very simple method of demonstrating the effect of centrifugal force on liquids of different densities (principle of cream separator). D is a cord about two meters long, doubled, and put through the holes of a two-holed rubber stopper, E. This stopper is jammed hard into the flask

* Drawings by Arthur Kirk, P. H. S., '17.

A, so that there will be no possibility of coming out. The liquids are mercury, and water colored with some dye, B. The screw-hook is screwed into a door frame or other convenient place high enough and the cord twisted by rotating the bulb between the palms of the hands. When it is so tightly twisted that kinks begin to appear, it is ready for use. On unwinding, the cord will give sufficient rotation to make the liquids take the positions shown in Figure 2. It is necessary to steady the cord a little just above the flask as the rotation gets rapid, because of the tendency to "wabble". This can be done with the first and second finger and thumb of one hand or by holding a small screw-eye as shown at F.

Figure 3 represents a device for showing that a body cannot float without water beneath it. The battery jar, A, has paraffin, F, poured in to make a bed for the plate glass, E. C is a cylinder of wood to which another plate of glass, D, is cemented with shellac. C and D together are of such weight as to float easily. But when they are pushed down upon the plate glass, E, they remain down, since there is no longer any upward pressure. When water leaks in between the plates, as it will do in a few minutes, the block floats again. This experiment is frequently done with mercury, but the lack of transparency of the mercury makes it impossible to show it to a large class this way.



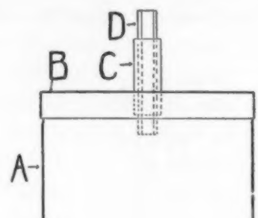


FIG. 4

Figure 4 represents a very simple device for demonstrating that although a mixture of combustible and supporter of combustion may burn, it will not *explode until the* PROPORTION of the ingredients is correct. A is a one-pound coffee can with a TIGHT-

FITTING cover. (Bend the cover to make a tight fit if necessary). Holes E, F, G, about one cm. in diameter are cut with a jack-knife blade. Into the top, B, is inserted a glass tube, D, 8 cm. long and 1 cm. internal diameter. To make the joint gas tight a piece of rubber tubing, C, is slipped over the glass tubing. The device is filled with illuminating gas by inserting a rubber tube into one of the holes in the bottom. When filled it is removed from the gas tubing and the gas issuing at the top of tube D, is lighted. It will burn with a yellow flame at first, denoting that only a small proportion of air is present, but will gradually burn bluer, due to the accumulation of air inside. Finally when the proportion is just right, the flame will be seen to descend in the glass tube and the whole canful of mixture will explode, blowing the cover several feet into the air.

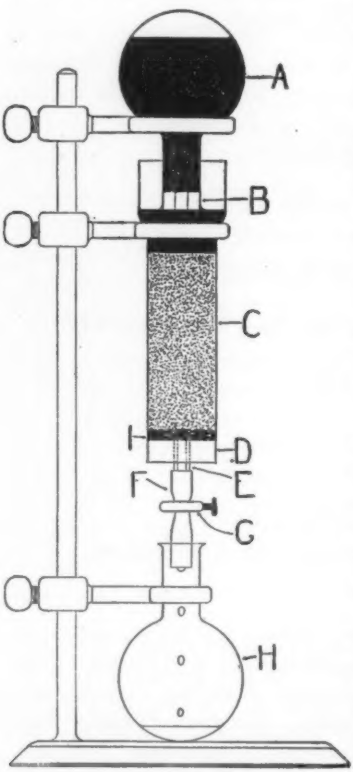


FIG. 5

The device shown in Figure 5 is an automatic decolorizing apparatus. It can be filled at the beginning of a lecture and by means of the stopcock, G, can be regulated to run slowly or rapidly. The student lamp chimney, C, is filled with granulated bone black on top of a layer, I, of excelsior. The flask A, is filled with a dilute solution of fuchsine or any other organic dye (red ink works well). The stopper, B, is necessary only as an aid in inverting, the large neck of the flask being too large to stop with the thumb. E is glass tubing inserted in D, a rubber stopper. F is rubber tubing and H a vessel of any clear glass. If the device is run properly, perfectly clear liquid only, comes into H.

General Science Bulletin *

(*Continued from page* 101.)

By Massachusetts Committee.

In the general unit, heat in the home, the following projects, demonstrations, laboratory exercises and topics may be included:—

A. Projects.

1. Construction.

   Fireless cooker. Fire extinguishers. Thermostat. Model heating systems. Model hot-water tank. Alcohol stove.

2. Interpretation.

   Gas stoves. Coal stoves. Steam heater. Alcohol stoves. Refrigerator. Matches. Oil stoves. Furnace. Hot-water heater. Hot-water tank. Ice-cream freezer. Gas meter.

B. Laboratory exercises and experiments.

The Bunsen burner.
What is the best fuel for a chafing dish?
Comparative cost of cooking by alcohol, oil and gas.
Is a high or a low gas flame more economical?
Study of a flame.
What is the best packing material for a fireless cooker?
Efficiency of a fireless cooker.
The fireless cooker as a refrigerator.
Testing thermometers.
Effect of surface on the rate of cooling.
Non-conductors—conductors.

C. Demonstrations.

The manufacture of illuminating gas.
Construction and operation of hand fire extinguishers.
How to read a meter.

D. Topics.

History of heating systems. Bunsen and the Bunsen burner. Natural gas. Gas manufacture and distribution. Central heating plants. Manufacture of alcohol. By-products of the gas works. Coal mining. The story of coal. How matches are made. Safety matches. Pyrometers. The making of a thermometer. Petroleum and its products.

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* Preliminary draft.

2. Our Water Supply.
   A. Projects.
      1. Construction.
         Filter for household use. Model of city filter.
      2. Interpretation.
         Study of reservoirs (location, physical features, elevations as shown by topographic maps, etc). Wells. Cisterns. Purification of water. Water storage and distribution. Hard and soft water. Water in vegetables. Springs.
   B. Demonstrations.
      Distillation. Model of water system. The cause of water pressure. Intermittent springs. The siphon. Pumps. Hydraulic press. Hydraulic ram.
   C. Laboratory exercises.
      Water tests. Charcoal as a filter. Efficiency of faucet filters. Tests for hard and soft water. Methods of softening water. Quantity of water in foods. Water pressure.
   D. Topics.
      Water-supply systems. Forests and water supply. Saving the water. National irrigation projects. Rivers of ice. The work of rivers. Work done by ice.
   E. General questions.
      Why do crackers become moist but bread dry in the same air?
      Why does a drowning person rise three times?
      How can fish live in a frozen pond?
      How cold is the water at the bottom of a frozen pond?
      Does the ocean ever freeze?
3. Cleansing and Dyeing.
   Making soap (laboratory or home). Making ink eradicators. Javelle water. Making cleansing fluids. Commercial dyeing. Bleaching of cloth. Other bleaching processes. A laundry. Physical and chemical changes. Solutions. Making of alcohol. Preparation of ammonia. Removal of stains. Alkalinity of soaps. Tests of washing powders, cleansing fluids, stain removers, etc. Dyeing of cloth, raffia, etc. (laboratory). Where do we get our dyes?

What are some of the different kinds of ink? How is benzine prepared? How is ether made?

4. Our Food Supply.

Making flavoring extracts. Preparation of starch. Coffee tests. Butter tests. Pasturized milk. Starch and sugar in foods. Color in foods. Sources of food supply. Making butter. Coffee growing. Making ice cream. Tests for coal-tar dyes. Other dye tests. Babcock milk test. Preservatives in milk. Food adulteration. Study of food preservatives. List of pure foods. Food values. A well balanced diet.

The food unit may be organized as follows in projects, demonstrations, experiments and topics:—

A. Projects.

1. Construction.

Preparation of different articles of food, as the baking of potatoes; boiling potatoes; roasting and boiling meats; making bread; canning and preserving foods; making up a menu for a family with estimates and costs, total and per capita.

2. Interpretation.

A study of sample menus given in newspapers or in cook books.

Report of the meals of a family represented in the class.

A study of the work of the local board of health as regards protection against poor food.

How the milk supply of the city is safeguarded.

Prices of different kinds of food. A study of patent cereals.

Estimates of costs of prepared foods against the same material in bulk.

B. Demonstration.

Tests of adulteration in foods. Various methods of preserving foods. Analysis of food materials, as proteins, carbohydrates or starches and sugar.

C. Laboratory exercises and tests of food adulterants by pupils.

Extraction of fats and oils by solution. Tests for various food materials.

D. Topics.

Adulteration of foods, including history. The government

Pure Food Bureau. Sources of food supply. The flour-milling industry. Cattle ranches of the west. The United States Fish Commission and its work. Fish hatcheries. Comparison of prices of food in this and other times.

Other food tests, and the study of the characteristics and value of various foods, may be made *ad lib*. In this connection it would not be out of place to consider—

Soil formation.

Action of glaciers, earthquakes, volcanoes, wind, water, chemical action, vegetation, temperature changes, avalanches, animals, human agencies, etc.

5. Our Animal Associates.

(*a*) Profitable.	(*b*) Harmful.
Bacteria.	Potato bugs.
Toads.	Elm beetle.
Birds, etc.	Gypsy moth.
Earth Worms.	Brown-tail moth.
Domestic Animals.	Flies and mosquitoes.
	The house cat, etc.

6. Keeping Well.

The sanitary house.	The sanitary town.
Sewers.	Preventable diseases.
Personal hygiene.	Preparation of food.
The teeth.	Tooth preparations.
Headache preparations	Habit-forming drugs.
Patent medicines.	Toilet preparations.

7. The Weather.

Study of almanacs.	Air pressure.	Dew.
Thunder storms.	Storm signals.	Frost.
Weather instruments.	Light ships.	Rain.
Weather maps.	Lighthouses.	Winds.

This general unit is available because of the universal interest in the subject. It affords an opportunity for a wide range of experimentation, observation and reading. The problems presented for consideration come within the range of the experience of boys and girls in general science classes. There is a wealth of material available for reading purposes. The study of the weather involves the examination, description, use and construction of certain instruments and devices which in turn suggest far-reaching scientific principles. The pupil is brought into direct contact with

phenomena of changes in form and substance, such as water to vapor; water to ice; rusting of iron; erosion of soil; deposit of silt. The desire for knowledge in this field is easily roused and gratified because of the background of experience possessed by the pupils. Further study and reading are easily stimulated. Among the projects included under the general unit of "weather" are the following:—

A. Projects.

1. Construction.

To make records of weather changes with or without instruments. To construct a rain gauge and make observations with it. To record data from government reports upon a map of the United States. To make a barometer.

2. Interpretation.

To compare almanac and official weather predictions. To compare actual weather conditions with almanac predictions. To find what predictions in an almanac are reliable and based on scientific data.

B. Demonstration.

The use of the hygrometer; wet and dry bulb reading; maximum and minimum thermometers.

How boiling point, freezing point and zero are determined. The aneroid barometer and its use.

C. Experiments.

Establishment of dew point. Proof that air contains moisture. Expansion of water on freezing.

D. Topics.

The government Weather Bureau. Superstitions relating to weather, including folklore, and an attempt to discover to what extent these sayings are based on actual facts. Description of government weather map. The local weather bureau and its work. Notable storms.

8. What Time is it?

Local time.	Noon by local time.	Time on the ocean.
Standard time.	Time by wireless.	School clock system.
Railroad time.	Time signals.	Clocks and chronometers.

A. Projects.

1. Construction.

Assemble parts of a clock. To make a sun dial. To

make an hourglass. To make a water clock. To study the mechanism of a watch.

2. Interpretation.

Various kinds of clocks. Chronometers and their use. How natural forces are used in the clock or watch. How does a pendulum regulate the time? Local devices for regulating watches and clocks.

B. Demonstrations.

The operation of a pendulum. How noon is determined by the sun.

C. Experiments.

The general law of the pendulum,—avoid emphasis on quantitative standards. Testing the accuracy of a watch or clock.

D. Topics.

A modern watch factory. The history of watches. Early devices for measuring time. Different calendars. Standard time in the United States. Daylight, a saving device. How small portions of time are measured. Stop watches. How the heavenly bodies may be used in determining time. Astronomical observations and time. Work of the Greenwich Observatory.

9. Ventilation.

How houses are ventilated. Measurement of the ventilation of a room at home. How our school is ventilated. Tests of the efficiency of school ventilation. Carbon dioxide in the air. Study of the air. Preparation of oxygen. Properties and uses of oxygen. The ventilation of theatres. Ventilation of public building. Ventilation of factories. Ventilation of stores. Ancient and modern methods compared.

10. Household Electrical Devices.

The electric toaster. Electric chafing dish. Electric flatiron. Electric bell. Electric stove. Electric coffee percolator. Electric water heaters. Burglar alarms. Efficiency and cost of operation of electrical devices as compared with similar devices operated by other means. Measurement of electricity by meters.

11. Commercial Uses of Electricity.

The electric telegraph. Its invention. Making a tele-

graph instrument. The Morse code. The use of the Morse code in heliographing and in other forms of signalling. The first Atlantic cables. A map of the ocean, showing the cable systems. Curiosities of long-distance telegraphing. How may money be sent by telegraph? The wireless telegraph.

The telephone. The description of a telephone. Making a telephone. Making a small telephone circuit. Description of the telephone of a city or town. Long-distance telphone.

Wireless telephone.

Electricity in an auto: the magneto; the spark coil,—how each operates.

Electromagnete in surgery and in factories and stores.

Electroplating. Electrotyping.

The sign flasher. Fire alarm systems. X-ray.

The story of electricity.

12. Transportation.

A wheelbarrow.	Steel rails.	Street cars.
Steam cars.	Removal of snow.	Automobiles.
Bicycles.	Good roads.	Motorcycles.
Boats.	Welding.	Aeroplane.

13. Our Neighbors in Space.

Practical value of the work of the astronomer.

The north star and the compass.	The moon.
Sunrise and sunset graphs.	The solar system.
The sun.	Constellations.
The stars.	Latitude by Polaris.
Comets and meteors.	Astronomical day.
North by Polaris.	Making a sundial.
Famous astronomers.	Sunshine recorders.

14. The House we live in.

The forests.	Imported woods.
Timber supply.	Characteristics of woods.
Bark. Charcoal.	Clay and bricks.
Wood alcohol.	Stone used for building.
Acetic acid.	Making concrete.
Forests and drainage.	Uses of concrete.
Forest fires.	Reinforced concrete.
Waste lands.	Glass. Slate. Mortar.

15. Street Lighting.

Gas arcs.
Kerosene lights.
Location of poles.
Measuring the light.
Electric light.
Cost of lighting streets.
Electric arcs.
Acetylene street lights.
Height of lights.
Incandescent lights.

History of its invention.
Description of an arc lamp.
Description of an incandescent lamp.
Different makes of incandescent lamps.
Making an electric light system.
The electric bell and other signals.
Use of electricity in railway signalling.
Great inventors in electricity: Edison, Faraday, Morse, Alexander Graham Bell.

16. Home Lighting.

Kinds of lights. Indirect lights. Effect on air. Location of lights. Lamp shades. Comparative costs. Quality of the light. Style of fixtures. Quantity of light.

17. Commercial Lighting.

Lighting of store windows. Decorative lighting of buildings. Special displays. Lighting of public buildings. Theatre lights and light effects. Dimming of lights. Illuminated signs.

18. Taking Pictures.

Making a camera. How to choose a camera. Light and silver salts. Gelatin printing. Ray filters. Taking the picture. Developing. Blue prints. Exposure meters. Lantern slides. Flash lights. Enlarging. The history of picture taking. Daguerre and his successors. Home portraits.

19. Insect Pests and How to Fight Them.

A. Projects.

1. Construction.

Destroying insect pests.
Observing the habits of some injurious insect.

2. Interpretation.

The life history of the gypsy moth; elm-tree beetle; potato beetle; grasshopper; locust.

B. Demonstrations.

Methods of fighting insect pests with local illustrations.

C. Experiments.

Operation of various substances used in fighting insects, as Paris green; tests for same. Caution against exposure to such poisons. A collection of warnings by government officials. Study of the life history of some insect. Collection of specimens.

D. Topics.

Literary and historical allusions to insect pests. The work of the government. The work of the State. Money losses.

20. General Questions.

In connection with the various units, interest and curiosity may be stimulated by the introduction of striking questions, and questions commonly asked but seldom answered. The following are examples:—

Of what value is odor to a flower?
Why have some flowers no odor?
Is the length of the day constant?
Why does not dew "fall" on a cloudy night?
Why is the seashore cool in summer?
Is night air dangerous to health?
Why does a bursting bag make a noise?
Where does the flame go when the candle is blown out?
Why does blowing put out a candle?
Why does a baseball curve?
What makes a balloon rise?
How high will a balloon rise?
Why does a breeze make us cool?
What color of wall paper is barred from an insane asylum? Why?
Why do cats always fall on their feet? Do they?
Why is it "darkest just before dawn?"
Why are colored globes used in windows of drug stores?
Why are barbers' poles striped?
Why is not a bird on a trolley wire electrocuted?
Where does the day begin?

(To be continued)

How Shall We Organize Our General Science?

By E. M. LIBBY, Presque Isle High School, Maine.

The great objection which is frequently raised against general science is that it is as yet an unorganized subject. The critics say, "You are teaching a lot of unrelated facts without regard to logical order." Another objection often raised is that "General science as usually taught at the present time is a good example of soft pedagogy, and soft pedagogy is dangerous."

The writer wishes in this brief article to give a few facts from his own experience relating to the two problems just mentioned. He has been experimenting upon this subject for several years and is now teaching about seventy-five high school freshmen. The class has copies of the Caldwell and Eikenberry text, but they are used only for reference work.

The form of organization which seems to me best is something very similar to the plan proposed and discussed in a recent number of the General Science Quarterly by Fred D. Barber. This scheme proposed that the science work for the first-year course be built up around the phenomena of the home, the street, the school, and, I would add, in this section, the farm.

I have learned by experience that the phenomena which will prove of greatest interest to the pupils are very likely not to be those which appeal to me. This year I asked my class to make lists of questions about the things which they saw about them every day and which they did not understand. The results which I obtained were very interesting and suggestive. I have a whole bundle of questions, covering every conceivable branch of natural science and yet dealing only with things and events familiar to the everyday lives of the young people. I took these lists of questions and am grouping together those which have a natural relation. For example there were very many questions having to do with electricity. I am trying to answer all of these by a brief—very brief—course in electricity, trying especially to touch upon explanations which answer the questions raised. In reply to the assertion that we are teaching simply a collection of facts, I would say that in any science the results will depend very largely upon the teaching. I think that the facts taught in such a course as I am describing *are* important, but I think that the attitude to-

ward scientific truth which may be developed is perhaps of still greater importance, and I believe that this may just as well be developed by the study of phenomena in which students have a present vital interest as in the consideration of truth which to them is more remote and abstract.

In reply to the assertion that our general science is an example of soft pedagogy and requires no work on the part of the student, I would say that we school teachers sometimes seem to think that no work counts except what we require to be done. I believe that the work of the world which counts most is work which is done because the worker is interested in it and wants to do it. I know that many of my science students are to-day reading scientific articles in text books and periodicals because they want to find out more about matters suggested in the class room, although this outside reading is merely suggested and in no way required. I suggest that for a high school freshman to master the subject of electro-motive force as explained in Milliken and Gale's Physics text book might be termed work, and I know that many of my class have done that with considerable success during the past two weeks.